Course ID: ECE 341 Communication Systems- Fall

Prof. Eirini Eleni Tsiropoulou
eirini@unm.edu / (505) – 277 – 5501
235D/ Office Hours: Mondays and Wednesdays 11:00am - 12:00pm
Lectures: Mondays and Wednesdays 9:30am-10:45 am, Room: EECE 118
Department of Electrical and Computer Engineering / University of New Mexico

Homework #4

Corresponding to Chapter 4 of Principles of Communications, Rodger E. Zimmer and William H. Tranter, John Wiley, 7th Edition.

1. Given that $J_0(5)=-0.178$, $J_1(5)=-0.328$, find $J_3(5)$ and $J_4(5)$.

2. A transmitter uses a carrier frequency of 1000Hz and the unmodulated carrier is $A_c\cos(2\pi f_c t)$. Determine the phase and the frequency deviation for the following transmitter outputs: a) $x_c(t)=\cos[2\pi 1000t+40\sin(5t^2)]$ and b) $x_c(t)=\cos[2\pi 1200t^2]$.

3. An FM modulator has output $x_c(t)=100cos[2\pi f_c t+2\pi f_d\int^t m(\mathrm{a})\,\mathrm{da}]$, where f_d=20Hz/V and $m(t)=4\Pi[(1/8)*(t-4)]$: a) Determine the phase deviation in radians and the frequency deviation in Hz, b) determine the peak frequency deviation in Hz, c) determine the peak phase deviation in radians, and d) determine the power at the modulator output.

To be delivered at instructor's office: 11 Nov. 2019

Good Luck!

1. Given that $J_0(5) = -0.178$, $J_1(5) = -0.328$, find $J_3(5)$ and $J_4(5)$.

$$J_0(5) = J_{n-1}(\beta) = -0.178$$

$$J_1(5) = J_n(\beta) = -0.328 \qquad \beta = 5$$

$$J_2(5) = J_{n+1}(\beta) \rightarrow n = 1$$

$$= \frac{2(1)}{5}(-0.328) - (-0.178) = 0.0468$$

$$J_3(5) = J_{2+1}(\beta) \rightarrow n = 2$$

$$= \frac{2(2)}{5} J_2(5) - J_{2-1}(5)$$

$$= \frac{2(2)}{5}(0.0468) - (-0.328) = \boxed{0.36544}$$

$$J_4(5) = J_{3+1}(\beta) \rightarrow n = 3$$

$$= \frac{2(3)}{5} J_3(5) - J_{3-1}(5)$$

$$= \frac{6}{5}(0.36544) - (0.0468) = \boxed{0.391728}$$

2. A transmitter uses a carrier frequency of 1000Hz and the unmodulated carrier is $A_c\cos(2\pi f_c t)$. Determine the phase and the frequency deviation for the following transmitter outputs:

a) $x_c(t) = \cos[2\pi 1000t + 40\sin(5t^2)]$

$f_c = 1000\text{Hz} \rightarrow A_c \cos(2\pi 1000t)$

$\phi(t) = 40\sin(5t^2)$

$$\frac{d\phi}{dt} = 400t\cos(5t^2)$$

b) $x_c(t) = \cos[2\pi 1200t^2]$

$A_c \cos(2\pi 1000t)$

$2\pi 1000t + \phi(t) = 2\pi 1200t^2$

$\phi(t) = 2\pi(1200t^2 - 1000t) = 2400\pi t^2 - 2000\pi t$

$$\frac{d\phi}{dt} = 2\pi(2400t - 1000) = 4800\pi t - 2000\pi$$

3. An FM modulator has output $x_c(t) = 100\cos\left[2\pi f_c t + 2\pi f_d \int^t m(\alpha)d\alpha\right]$, where f_d =20Hz/V and $m(t) = 4\Pi[⅛(t-4)]$

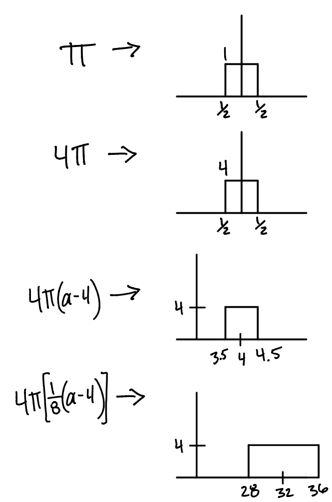
a) Determine the phase deviation in radians and the frequency deviation in Hz

$$\phi(t) = 2\pi(20)\int^t 4\pi\left[\tfrac{1}{8}(\alpha-4)\right]d\alpha$$
$$= 40\pi\int^t 4\,d\alpha$$
$$= 40\pi(4t)$$
$$= 160\pi t \text{ rad}$$
$$\frac{1}{2\pi}\frac{d\phi}{dt} = 160\cancel{\pi}\left(\frac{1}{2\cancel{\pi}}\right)$$
$$= 80\text{ Hz}$$

b) Determine the peak frequency deviation in Hz

$$\frac{d\phi}{dt} = 80\text{Hz}$$

c) Determine the peak phase deviation in radians



$$\phi(t) = 2\pi(20)\int^t 4\pi\left[\tfrac{1}{8}(\alpha-4)\right]d\alpha$$
$$= 40\pi\int_{28}^{36} 4\,d\alpha$$
$$= 160\pi t\Big|_{28}^{36}$$
$$= 1280\pi \text{ rad}$$

d) Determine the power at the modulator output

$$\langle x_c^2\rangle = \frac{A_c^2}{2} = \frac{(100)^2}{2} = 5000\text{W}$$